New Horizons in Globular Cluster Astronomy
ASP Conference Series, Vol. ???, 2002
Giampaolo Piotto, George Meylan, George Djorgovski and Marco Riello, eds.

Dynamical Evolution of Globular Clusters in the Magellanic Clouds and Other Local Systems

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Abstract. Observations of rich LMC and SMC clusters reveal an increasing spread in core radius (r_c) with age. This trend likely represents real physical evolution in these systems. Old clusters appear either large or small. Similar r_c distributions are observed for the Fornax and Sagittarius dSph cluster systems and in the "young" halo Milky Way subsystem. These observations have implications for the formation of the Galaxy and the dynamical evolution of globular clusters.

1. Globular Clusters in the Magellanic Clouds

The Large and Small Magellanic Clouds (LMC/SMC) possess rich stellar clusters of masses comparable to Milky Way globular clusters (MWGC), but with ages $10^6 \leq \tau \leq 10^{10}$ yr. These two systems therefore permit direct observational studies of globular cluster evolution. We have assembled and reduced archival Hubble Space Telescope (HST) data for 53 LMC and 10 SMC clusters spanning the full age range, and have measured parameters such as the core radius (r_c) and the total mass and luminosity for each cluster using surface brightness profiles (Mackey & Gilmore 2002a; 2002b). Our results, Figure 1(a), show a clear trend in r_c with increasing age for both systems, including an apparent bifurcation of the distribution at $\tau \sim 10^8$ yr so that old clusters may have either large or small r_c. As discussed in Mackey & Gilmore (2002a, 2002b), we conclude that the observed trend with age represents genuine physical evolution of clusters in these two systems. The mechanism by which some clusters undergo large scale core expansion while otherwise similar clusters do not is as yet unidentified, and we are exploring possibilities via N-body simulations.

2. Globular Clusters in nearby dSph galaxies and the Milky Way

Another avenue of investigation is to observe whether any other local systems show globular clusters with expanded cores. Unlike the LMC/SMC clusters, all other local globular clusters are old ($\tau \sim 10^{10}$ yr). Fornax and Sagittarius (Sgr) are the two most massive dSph galaxies associated with the Milky Way, and the only two to have globular clusters. Fornax has five (C1-C5) while Sgr has four (M54, Ter 7, Ter 8, Arp 2) plus one clearly previously associated (Pal 12). Again using archival HST data, we have measured r_c of 10.0 pc, 5.8 pc, 1.6 pc, 1.8 pc, and < 1.4 pc for Fornax C1-C5 respectively (Mackey & Gilmore 2002c). Like the old LMC/SMC clusters, these clusters are either

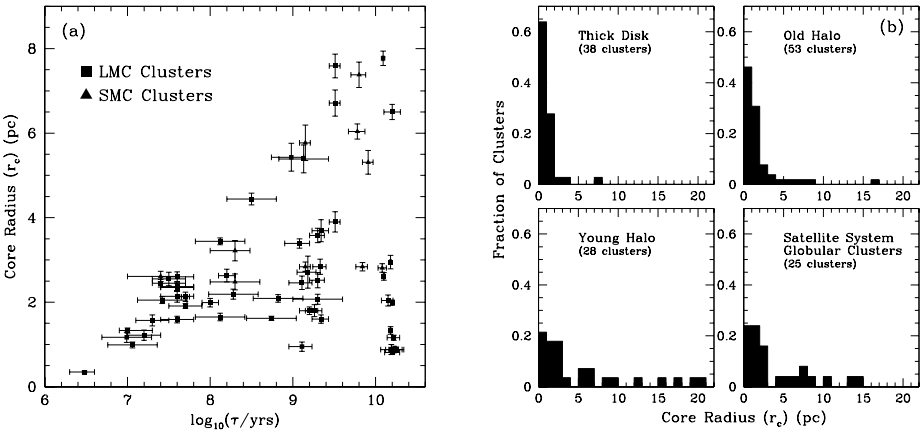

Figure 1. (a) r_c vs. age for our combined LMC/SMC sample. (b) Binned r_c distributions for the three MWGC subsystems of Zinn (1993) and the combined "satellite" system.

compact ($r_c \leq 3.5$ pc) or expanded ($r_c \geq 5.5$ pc). From the catalogue of Harris (1996) the Sgr clusters have r_c of 0.9 pc, 4.1 pc, 7.6 pc, 13.2 pc, and 1.1 pc for M54, Ter 7, Ter 8, Arp 2, and Pal 12 respectively. We again observe a similar r_c distribution. We also examine the MWGC system, using the data of Harris. The MWGC system may be split by [Fe/H] and horizontal branch type according to the prescription of Zinn (1993). Plotting binned r_c distributions for each subsystem, Figure 1(b), we see each is distinct, with the "young" halo subsystem containing the majority of clusters with large cores. We can form a composite "satellite" system, containing the old LMC/SMC clusters, and the Fornax and Sgr dSph clusters. The r_c distribution for this system appears very similar to that for the "young" halo subsystem. A simple K-S test shows the unbinned distributions to be similar at $\sim 93\%$ significance. The satellite system and the thick-disk and "old" halo subsystems are different at 99.9% and 99.8% significances respectively. This result supports Zinn's (1993) hypothesis that the "young" halo clusters have been accreted from destroyed satellite galaxies, while the thick-disk and "old" halo clusters are mostly intrinsic to the Milky Way. Alternatively, if one already accepts this picture, our result shows that clusters with large cores do not survive (or perhaps form) in regions with strong tidal fields. Core expansion may therefore be exclusively a weak-field effect.

References

Harris, W. E. 1996, AJ, 112, 1487

Mackey, A. D., & Gilmore, G. F. 2002a, MNRAS, in press (astro-ph/0209031)

Mackey, A. D., & Gilmore, G. F. 2002b, MNRAS, in press (astro-ph/0209046)

Mackey, A. D., & Gilmore, G. F. 2002c, MNRAS, submitted

Zinn, R. 1993, in ASP Conf. Ser. Vol. 48, The Globular Cluster-Galaxy Connection, ed. G. H. Smith & J. P. Brodie (San Francisco: ASP), 303